

Machina Research

White Paper

M2M growth necessitates a new approach to network planning and optimisation

May 2015

1 Executive Summary

Growing numbers of machine-to-machine (M2M) connected devices, as part of the emergence of an Internet of Things, will create challenges for Mobile Network Operators. The absolute volume of devices and mobile network traffic will be ostensibly quite manageable, with M2M accounting for just 19% of connections and 4% of traffic. However, traditional handsets, tablets and mobile broadband connections are relatively homogenous in their demands, in terms of usage, geographical location, criticality, security and numerous other criteria. M2M devices are much more diverse. As a result, M2M devices have the potential to place completely different demands on the network.

This White Paper provides a snapshot of the growth of M2M/IoT in terms of numbers of devices and traffic, examines the ways in which M2M can put different and unexpected strains on the network, with a particular focus on connected cars, and finally offers some perspectives on how this might necessitate some changes in network engineering and operations.

The key findings are as followings:

- The growth in M2M devices will be substantial, with cellular connections increasing from 250 million to 2.3 billion in the next decade. Traffic will grow even more quickly from 200 petabytes in 2014 to 3.2 exabytes in 2024. However, M2M will account for only 4% of all cellular traffic in 2024.
- M2M devices do not behave in the same way as handsets, tablets and other more established mobile devices. This may result in less manageable traffic patterns at particular times and in particular locations. For instance, our analysis of the connected car market shows that peak traffic in the busy hour in certain cells could double as a result of the numbers of connected cars.
- Other applications have equally diverse requirements that could create challenges for MNOs, for instance: highly distributed agriculture applications having greater demand for rural coverage; healthcare or supply chain applications demanding more reliable connections to support life- or mission-critical applications; certain applications demanding reduced latency to enable real-time analytics; and proportionally greater signaling overhead from low traffic monitoring applications.
- M2M growth necessitates intelligent network engineering and operations. There are a number of ways in which MNOs should rethink their approach to running their network to cope with M2M growth. These include implementing more dynamic network management and RAN optimization, supporting more diverse access networks, adopting more sophisticated planning tools, and taking a more considered approach to spectrum refarming.

The growth of M2M has changed the rules of the game with regard to supporting devices on mobile networks. Any MNO that continues to plan and run its network without consideration for the requirements of M2M in all its diversity will suffer knock-on effects, either in terms of its ability to tap into this new revenue opportunity, or the side effects that it may have on user experience for all the users of the network.

2 M2M growth will be substantial

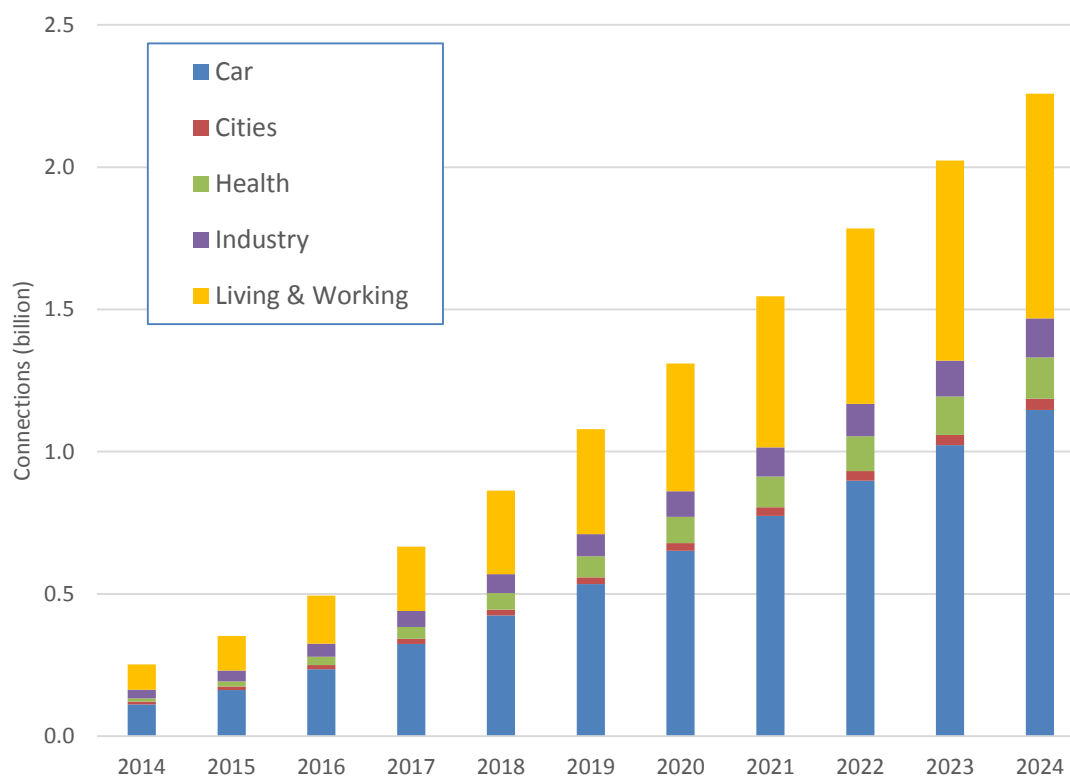
One of the defining trends that will dominate the telecoms industry in the next ten years is the growing demand for connecting new types of devices.

The falling cost of connectivity and hardware is creating an environment in which numerous sectors are exploring the benefits of using machine-to-machine (M2M) connectivity. Motivations are incredibly diverse, including increasing the efficiency of business processes, adding new product features, build closer relationships with customers, and facilitating whole new business models. Historically the focus has been on the more mundane efficiency savings, but increasingly companies are seizing the opportunity to use embedded intelligence and connectivity to switch from selling products to selling services.

Increasingly the term ‘Internet of Things’ is being used to define this space. For Machina Research, the IoT is facilitated by the creation of lots of interlinked M2M devices along with numerous other data sources.

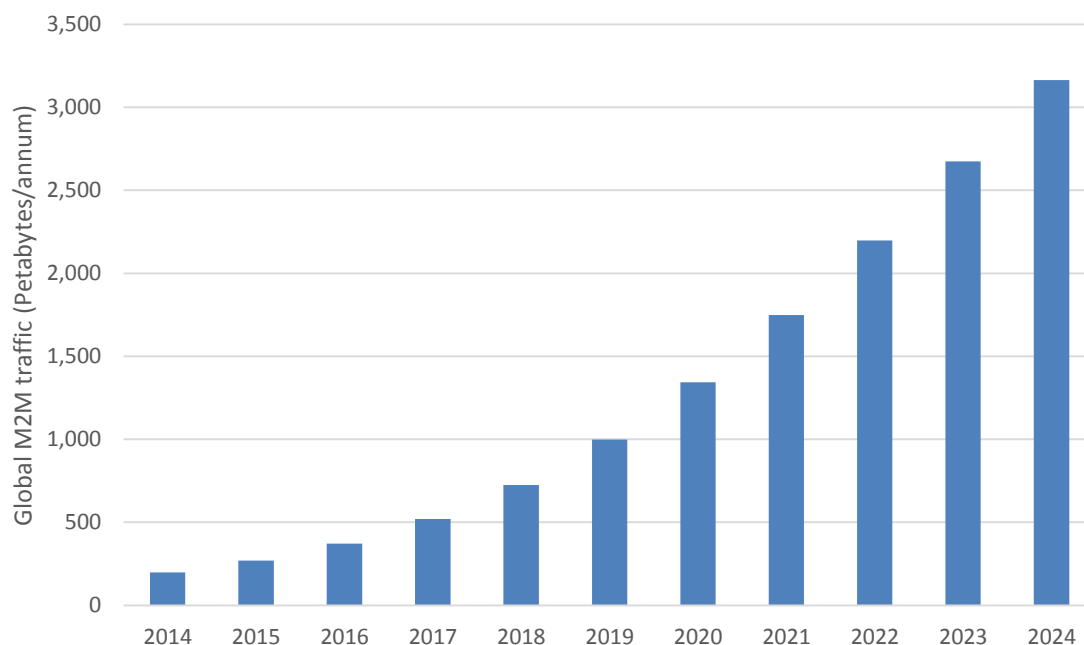
In total Machina Research forecasts that there will be 29 billion M2M connections by 2024, up from 4.5 billion in 2014. Cellular networks will support only a minority of these connections, but, as illustrated in Figure 2-1, the growth will still be considerable, from 250 million in 2014 to 2.3 billion in 2024.

Figure 2-1: Global cellular M2M connections 2014-24 [Source: Machina Research, 2015]



Based on this growth in cellular connected devices, as well as large numbers of short-range connected devices which use cellular as a backhaul network, the amount of cellular traffic generated by M2M will grow from 200 petabytes per annum to 3.2 exabytes per annum between 2014 and 2024.

Figure 2-2: Global cellular M2M traffic 2014-24, PB/annum [Source: Machina Research, 2015]



3 Traffic growth from M2M, particularly from connected cars, will cause headaches for mobile network operators

As noted in Section 2, above, the growth of M2M connections and traffic will be substantial, and mobile network operators are increasingly gearing up to support these new types of connected devices. At first glance, however, the total amount of cellular traffic generated does not seem particularly substantial. Courtesy of the continuing growth in smartphone and tablet usage, and greater mobile broadband adoption, the majority of traffic will continue to be generated by these existing more traditional cellular devices. In 2014, approximately 2% of traffic was generated by M2M, a figure which will increase to 4% in 2024. In this context it would appear that cellular operators have little to worry about in terms of supporting M2M devices on their networks. However, the picture is not quite that simple. While M2M devices may not necessarily generate huge volumes of data, these devices have their own particular demands.

M2M devices do not behave in the same way as traditional cellular devices. The result being that traffic patterns are likely to be very different, which will create some challenges for network

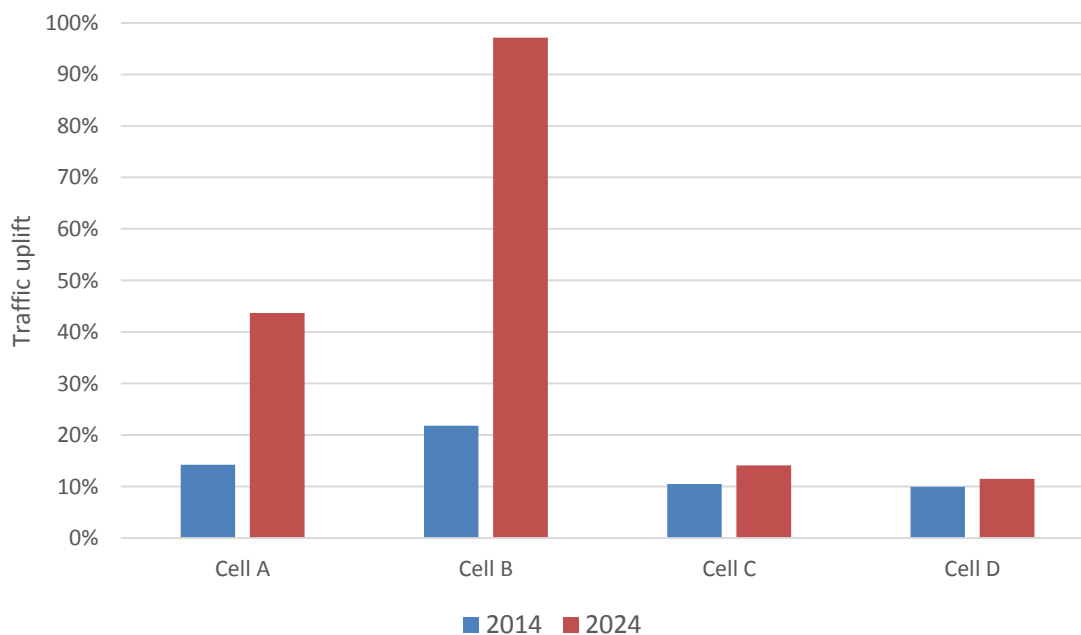
management. In terms of overall volume of data, M2M growth does not appear to pose much of a problem, but network resource management is not based on the total volume of traffic, it is based on demand on particular cell sites during peak times of traffic use. While it might not be economically viable to support every possible peak in traffic demand, it should be noted that if M2M devices regularly generate spikes in usage in a particular location which cannot be met, there are implications for customer satisfaction, and even the risk of non-compliance with service level agreements (SLAs).

In this study, we have modelled the demand for cellular data traffic in a few example cell types during the busy hour. Over the period 2014 to 2024 the average traffic demand in a specific location will increase approximately 6-fold due to increasing use of data devices and new connected devices. This is a challenge that MNOs know about and have strategies in place to deal with. 3GPP enhancements and the availability of more spectrum will allow them to cope with this requirement.

However, the introduction of lots of new M2M devices creates a new set of parameters for demand for network resources. In this study, Machina Research looks at one particular instance in which the growth of M2M may cause some challenging spikes in data traffic. Specifically this relates to high demand for connected car applications during periods of heavy vehicle traffic. Section 5, below, outlines the methodology used, but here we present the main results.

Today, with the current blend of devices, i.e. mostly smartphones, we estimate that traffic peaks created by cells with a lot of vehicle traffic congestion might result in a 10-22% uplift in data traffic. By 2024, in certain cells, the equivalent figure, due to large amounts of connected cars, could be as high as 97%. Put simply, connected cars create a situation in which maximum busy hour demand could be twice as great as average busy hour demand in 2024. This compares to a maximum 22% higher in 2014.

Figure 3-1: Traffic uplift in four cell scenarios during the busy hour with road traffic congestion
[Source: Machina Research, 2015]



So, as a result of the analysis we can predict that in certain cells, usage spikes caused by connected cars will inflate the peaks in mobile data traffic demand substantially.

This is, of course, only one example of a set of applications within M2M that will have an effect on network requirements, and only in one way, i.e. spikes in data usage. There are many other examples where demand from M2M devices will create unusual demands on cellular network resources that MNOs will need to resolve, for instance:

- **More distributed deployments.** M2M applications will not necessarily be located in the same places as people. Many, such as smart metering or consumer electronics, map very neatly to where people live. Others will not. Agricultural applications, for instance, will create clusters of additional demand in previously lightly-covered rural areas.
- **Greater demand for more reliable connections.** While connecting handsets, tablets and mobile broadband on a best-effort basis was acceptable, for M2M applications this may not be sufficient. Many applications are mission-critical, supporting supply chain efficiency, or handling payments. Others, most notably in the healthcare vertical, support life-critical applications. Here, best effort might not be enough. It should also be noted that these mission-critical applications have the potential for carrying a substantial ARPU, making them appealing to MNOs.
- **Near-real-time data analytics.** This is related to the previous bullet, but increasingly within the Internet of Things, applications will want to institute real-time feedback between servers and applications based on analysis of the data coming from those applications. An example might be retail signage reacting to buyer behaviour. Another might be white goods or HVAC (heating, ventilation and air conditioning) systems that react to dynamic electricity pricing information supplied to the smart meter. These devices will need to act increasingly in real-time, providing a greater demand for more robust systems with lower latency. It should be noted that actual real-time applications such as vehicle-to-vehicle communications, or remote surgery, are likely to be beyond cellular networks which will always be subject to the vagaries of the radio access network.
- **Different traffic patterns.** Handsets, tablets and mobile broadband devices have typically four types of traffic patterns: voice calls, high volume data sessions, low volume messages, and low volume updates. Mobile networks have been provisioned to cope with these types of communications. M2M devices generate traffic with many alternative patterns. In a lot of cases the device is simply sending a network ping to say 'I am here', or is reporting simple data on a regular basis. In both cases, the signaling overhead associated with the communication is substantial, given the very low volume of data being sent.

Machina Research has been examining the diversity of M2M applications in a lot of detail¹, and the overwhelming message is that this is a sector characterized by diversity. In fact it is so diverse that it doesn't qualify as a sector at all. It is a range of different use cases that may benefit from connectivity. The above represents a small cross-section of the possible ways in which traffic created by M2M will generate new and different demands on the network.

¹ See <https://machinaresearch.com/news/press-release-new-study-from-machina-research-maps-the-dna-of-m2m/> for more on this research.

4 M2M growth necessitates intelligent network engineering and operations

As identified in the sections above, the growth in M2M devices will have significant implications for mobile network operators and how networks are provisioned. This will not be particularly due to the amount of traffic generated but more where it is generated, when it is generated, the types of traffic generated and the criticality of the traffic. The result is that MNOs will often need to give more serious consideration to how to cope with demands for reduced latency, higher bandwidth, proportionately more signaling, and higher QoS.

In this section we examine how MNOs should adjust their approach to running their network to reflect the new reality. As noted in Section 3, above, the main challenge associated with the growth of M2M relates to the diversity of demands on the network, which has the potential to create headaches for the MNOs seeking to support them.

There are a number of ways in which MNOs should think about network engineering in order to cope with the expected take-off in M2M connections:

- **Dynamic network management and RAN optimisation.** As illustrated in the example above M2M has the potential to create more substantial peaks and troughs in data usage than more traditional cellular services have. As such, managing resources on the cell level will become more challenging. This applies both to the RAN and to backhaul. In particular there will be a substantial variance in the demands that different devices have for network resources and QoS. This necessitates a multi-faceted approach to network management that can cope with the varying demands of different device types for network capacity and quality of service.
- **Support for greater diversity in access networks.** MNOs are increasingly going to need to support devices connected to a variety of different access networks, as appropriate to reflect the requirements of the application. Connected home applications, for instance, will demand WiFi, while remote low power sensors might be more appropriately connected via one of the new Low Power Wide Area (LPWA) networks. MNOs will be adding more access networks to their portfolio and they will need to manage them, and the inter-relationship between them, effectively. A sub-issue here is that several different types of spectrum will be used, including traditional licensed spectrum, unlicensed ISM band, white space shared spectrum, and potentially some private or pseudo-private networks.
- **An increased focus on device management.** As M2M grows, the number and diversity of devices connecting to a network will increase exponentially. Each of these devices has the potential to introduce interference into the network and degrade quality of service for all other users. A robust certification process for all devices connecting to the network will be required as will service assurance capabilities which can identify devices causing degradation on the network.
- **More sophisticated planning tools.** The new reality for MNOs is that within the next 10 years in some cells up to two-thirds of connections might be M2M. MNOs need planning

tools that reflect this diversity and allow for suitably advanced forecasting, capacity planning and modelling, in particular taking account of issues such as varying QoS and different access technologies, as outlined in the bullets above.

- **More considered approach to spectrum refarming.** M2M devices are more sensitive to spectrum refarming. They will often have lifespans measured in decades and be in hard-to-reach places where it is expensive to swap them out. As a result, MNOs will need to be more considerate of how they refarm spectrum and the impact it will have on the installed base of M2M devices.

The implication is that to properly get to grips with the growth of M2M, MNOs will need to give more consideration to planning and running their network.

5 Methodology

This assessment of the impact of traffic growth from M2M connections is based on data extracted from Machina Research's M2M Forecast Database, which looks at total market growth, supplemented with cell-level analysis to identify the impact that M2M connection and traffic growth might have on the traffic within a specific cell.

5.1 The Machina Research M2M Forecast Database

Machina Research has the most granular forecasts of the M2M and IoT market opportunities. Our methodology is highly rigorous, based on extensive data gathering and analysis. It is also very granular, with analysis of around 200 different applications for every country in the world. The ten year forecasts include numbers of connections, technologies splits and the associated traffic and revenue². Particularly relevant to this study, one of our key sectors is 'Connected Car', where we track and forecast 11 different applications (including the likes of entertainment, fleet management, navigation, stolen vehicle recovery, usage-based insurance, and vehicle diagnostics). This includes analysis of both factory-fit embedded connections and the applications supported on those connections, as well as application-specific 'aftermarket' devices, added into the vehicle after production³. Under the umbrella of Connected Car we also include assessment of commercial vehicles and motorcycles.

² For more information on the M2M Forecast Database, see <https://machinaresearch.com/what-we-do/advisory-service/m2m-forecast-database/>

³ For more information on our Connected Car research, see <https://machinaresearch.com/what-we-do/advisory-service/connected-car/>

5.2 Peak demand analysis

The M2M Forecast Database gives us a starting point for the total amount of traffic generated by M2M devices (as well as PCs, handsets, tablets and other more traditional devices). Clearly the volumes of such traffic are growing substantially (as illustrated in Section 2, above). However, looking at the total amount of traffic misses the main impact. More important is how much impact M2M will have on traffic generated in specific cells during the busy hour (i.e. what is the peak demand that the network will have to manage).

The key measure of impact of M2M growth in network capacity should relate to peak demand in a specific location. Our hypothesis is that abnormal additional load from particular types of device might cause significant spikes in demand. This would only apply to certain M2M applications. Many, such as smart meters, home automation, vending machines or road sensors, are either predictable or manageable, both in terms of where the devices will be, and how much traffic they might generate. Where traffic is predictable, so is network resourcing. However, there are applications where device location might be unpredictable, such as agriculture, where large amounts of monitored cattle might suddenly appear on a cell. Similarly there are applications where volume of usage might spike based on less-than-predictable factors; an example might be blue-light services attending an emergency, which might also be combined with a spike in alarms and other traffic.

One set of applications is potentially subject to both trends: automotive. With regard to cellular networks, the single biggest set of applications, both in terms of connections and traffic is in automotive. And it is notable that they are subject to spikes in usage (based on user interaction and various other factors), as well as the potential for having large numbers of devices appear in clusters in particular locations.

The question is: might the growth in connected cars cause significant uplift in traffic in particular areas in less-than-predictable ways, and will this have an impact on user satisfaction? Boiled down: could traffic jams result in a significant spike in data usage in particular cells, which might cause dropped data sessions and increased customer dissatisfaction, and will MNOs have to act to cope with those unevenly distributed abnormal additional loads?

5.3 Modelling assumptions for automotive M2M impact on localised traffic demand

The exercise undertaken for this study therefore involves modelling the impact that unpredictable patterns for connected cars might have on total mobile network traffic in particular localised areas, i.e. individual cells.

The starting point for the modelling is four types of cells:

- Urban
- Sub-urban with major arterial road
- Sub-urban

- Rural

For each of those we made assumptions about size, number of people, KM of road, cars per KM of road, etc. We model traffic for four types of device: handsets/tablets, PCs/laptops (mobile broadband), automotive, and other M2M. The key assumptions are listed in Figure 5-1 below.

Figure 5-1: Key modelling assumptions [Source: Machina Research, 2015]

	Cell A	Cell B	Cell C	Cell D
Location	Urban	Sub-urban	Sub-urban	Rural
Road traffic patterns	Typical urban traffic	Major arterial road	No major arterial road	No major arterial road
Area of cell sector (sqm)	500	1000	1000	5000
People per sqkm	2000	500	500	50
Length of arterial road (in m) per sq km*	3,000	6,000	0	0
Length of other road (in m) per sq km	10,000	2,000	2000	200
Cars per km of road (normal)	50	100	25	10
Cars per km of road (busy)	200	300	50	20
Handsets per person	1.2	1.2	1.2	1.2
MBB devices per person	0.11	0.11	0.11	0.11
Car connections per car ⁴	0.1	0.1	0.1	0.1
M2M connections per cell	80	80	80	80
People per car	1.5	1.5	1.5	1.5
People living in the cell	1000	500	500	250

All of this modelling, and these assumptions, relate to a typical developed market in North America, Europe or Asia-Pacific. The dynamics will be slightly different for emerging markets.

For non-auto 'Other M2M' we assume, for the purposes of this model, an even distribution of the connections across all cells, so starting from ~80 M2M connections per cell in 2014, growing to over 700 in 2024

It should be noted that for the purposes of this modelling, we are considering a market leading mobile operator with 1/3 market share in traditional devices (i.e. handsets, tablets and mobile broadband), 75% share of connected car, and 50% of other M2M.

In this analysis we are interested only in the busy hour, i.e. 5pm-6pm, and the traffic generated therein. We assume 6.25% of traffic from traditional devices is generated during that period. For automotive we assume the equivalent figure is 12.5%. For M2M we assume a completely even distribution across the 24 hour period, either because of even reporting periods, or because of deliberate time-shifting to off-peak periods.

⁴ This is a figure for 2014, based on approximate connections compared to numbers of vehicles in developed markets. Over the forecast period this will increase substantially, to ~0.8 in 2024.

The purpose of this modelling is to identify not just the typical dynamics, as identified above, but the delta between that and peak usage cause by two things:

- **More devices in the cell.** Clearly during the traffic jam scenario, there will be greater numbers of devices in the cell. Phones and tablets could increase by 20%, while numbers of connected cars could be up as much as 3-fold, as illustrated in Figure 5-2, below.
- **More traffic per device.** We also assume that individual devices will be generating proportionately more traffic than in periods of lighter road use. This will be due to factors such as greater user demand for entertainment, more need for communication, and searching for navigation options.

Figure 5-2: Cars per KM of road, busy vs normal, by cell type [Source: Machina Research, 2015]

	Cell A	Cell B	Cell C	Cell D
Location	Urban	Sub-urban	Sub-urban	Rural
Road traffic patterns	Typical urban traffic	Major arterial road	No major arterial road	No major arterial road
Cars per km of road (normal)	50	50	20	10
Cars per km of road (busy)	100	150	30	20

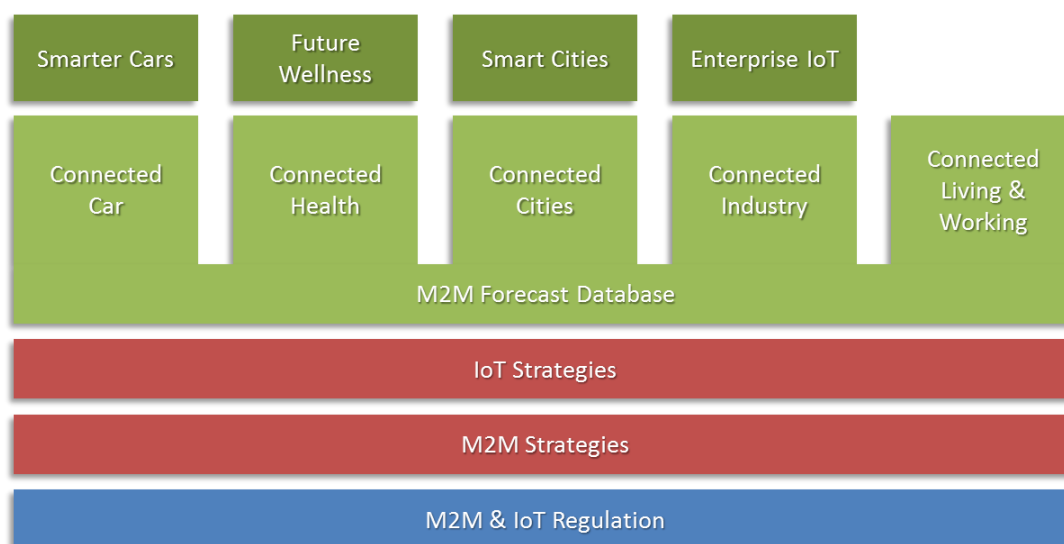
6 About Machina Research

Machina Research is the world's leading provider of market intelligence and strategic insight on the rapidly emerging Machine-to-Machine (M2M), Internet of Things and Big Data opportunities. We provide market intelligence and strategic insight to help our clients maximise opportunities from these rapidly emerging markets. If your company is a mobile network operator, device vendor, infrastructure vendor, service provider or potential end user in the M2M, IoT, or Big Data space, we can help. We work in two ways:

- Our **Advisory Service** consists of a set of Research Streams covering all aspects of M2M and IoT. Subscriptions to these multi-client services comprise Reports, Research Notes, Forecasts, Strategy Briefings and Analyst Enquiry.
- Our **Custom Research and Consulting** team is available to meet your specific research requirements. This might include business case analysis, go-to-market strategies, sales support or marketing/white papers.

Machina Research's Advisory Service provides comprehensive support for any organisation interested in the Internet of Things (IoT) or Machine-to-Machine (M2M) market opportunity. The Advisory Service consists of thirteen Research Streams (as illustrated in the graphic below), each focused on a different aspect of IoT or M2M. They each provide a mixture of quantitative and qualitative research targeted at that specific sector and supported by leading industry analysts.

Advisory Service Research Streams [Source: Machina Research, 2014]



Machina Research's analysts also have a wealth of experience in client-specific consultancy and custom research. Typical work for clients may involve custom market sizing, competitor benchmarking, advice on market entry strategy, sales support, marketing/promotional activity, and white papers.

For more information, refer to our website at <https://machinaresearch.com>, or email us at enquiries@machinaresearch.com.